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Minimally Invasive Lumbar Decompression

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Lumbar spinal stenosis (LSS) is one of the most common diseases of the spine that affects the elderly population. Verbiest [1] first described this syndrome in the early 1950s; however, controversy exists in regard to symptomatology and diagnosis (clinical versus radiologic) as well as choice of treatment. The syndrome is the result of a multitude of degenerative changes that occur as the body ages. The combination of disc degeneration, facet arthropathy, and ligamentum flavum hypertrophy leads to a narrowing of the spinal canal, causing compression of the neural elements (Fig. 1). Patients with lumbar stenosis may present with symptoms that include low back pain, radiculopathy, motor or sensory deficits, or intermittent claudication that usually worsens with walking [2]. Because this condition occurs gradually over years, it rarely leads to acute neurologic deficits.

Initially, most patients can be managed with conservative nonoperative therapy. Aggressive physical therapy regimens, epidural steroid injections, and weight loss may provide some patients with significant relief of their symptoms [3,4]. If conservatively treated patients do not exhibit improvement, decompressive surgery may be considered. Traditional surgical treatment includes posterior decompressive laminectomy. This procedure involves surgical resection of the spinous process, lamina, and part of the facet as well as disruption of the supraspinous and interspinous ligaments. Novel minimally invasive approaches that limit disruption of the surrounding tissue have become increasingly popular treatment options in patients with symptomatic lumbar stenosis.

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Historical perspective of spinal stenosis and treatment

Perhaps one of the earliest examples of an operation to relieve spinal stenosis was reported by Lane [5] in 1893, when he successfully decompressed a patient with cauda equina syndrome secondary to spondylolisthesis. In 1913, Elsberg [6] also documented an early case of a patient with lower extremity pain and left leg weakness that was cured after he performed a laminectomy. It was more than 30 years after these early reports that Verbiest [1] finally described the syndrome associated with narrowing of the lumbar spinal canal. To delineate the cause, Arnoldi and colleagues [7] devised an international classification of lumbar stenosis that consists of (1) degenerative, (2) congenital, (3) combined, (4) spondylolytic spondylolisthesis, (5) iatrogenic, and (6) posttraumatic stenosis.

There are numerous case series that report a high success rate in patients undergoing an open decompressive laminectomy, but the results seem to lessen over time [8–10]. One prospective observational cohort study is the Maine Lumbar Spine Study. The study enrolled 148 patients, of whom 81 were treated surgically and 67 were treated nonsurgically. Atlas and coworkers [11] reported that 28% of nonsurgically treated patients and 55% of surgically treated patients reported a definite improvement in their predominant symptoms. The maximal benefit was observed at 3 months. A report of this group after evaluation at 4 years demonstrated that 70% of the surgically treated patients and 42% of the nonsurgically treated patients reported improvement in their predominant symptom [12]. Of the 148 patients enrolled, 105 were alive at 10 years. Eight- to 10-year follow-up data were available for 56 of

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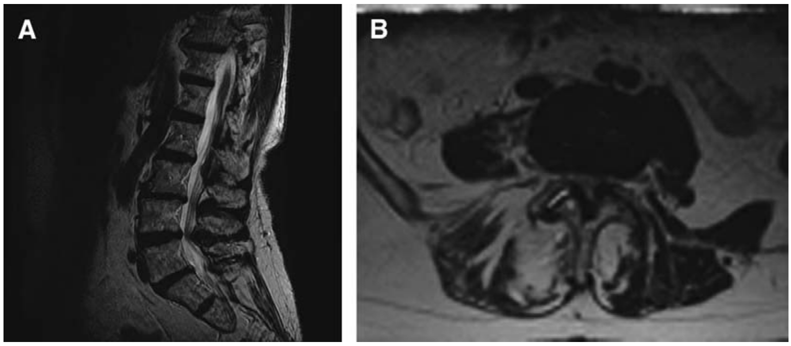

Fig. 1. MRI demonstrating sagittal (*A*) and axial (*B*) imaging characteristics of spinal stenosis, including a degenerative intervertebral disc, ligamentum flavum hypertrophy, and facet arthropathy causing severe narrowing of the lumbar spinal canal.

the 63 surgically treated patients and for 41 of the 60 nonsurgically treated patients. A similar percentage of surgical and nonsurgical patients reported that their back pain was improved, 53% and 50%, respectively. Interestingly, by 10 years, 23% of the surgical patients had undergone at least one lumbar spine operation and 39% of the nonsurgical patients had undergone at least one lumbar spine operation [13].

Patients who undergo an open decompressive laminectomy may develop worsening of their symptoms, thus requiring another operation. The reoperation rate has been reported to be approximately 10% to 23% [14–16]. Jansson and colleagues [16] reported 1-, 2-, 5-, and 10-year reoperation rates of 2%, 5%, 8%, and 11%, respectively, in 9664 patients who underwent decompression for stenosis in Sweden. The procedure has also been reported to be safely performed in the older medically frail population [17–19].

Less invasive modifications for decompression

The emphasis on reducing the iatrogenic damage to the surrounding soft tissue as well as preserving the supporting ligaments and paraspinal musculature led to the development of various ''less invasive'' procedures. The preservation of the supraspinous ligament by performing a bilateral laminotomy as well as unilateral approaches was reported by Joson and McCormick [20] in 1987. Modifications of this less invasive approach have been well documented in the literature, with reported excellent clinical results and low morbidity [21–30]. Unique techniques, including ''spinous process-plasty'' and spinous process osteotomies, have been reported to offer a less invasive treatment option with a purported stabilizing effect. These procedures have also been reported to offer a good clinical outcome [31–34].

Technologic advances have paved the way for novel less invasive surgical treatments for spinal stenosis. Improvements in fiberoptic and endoscopic technology have provided surgeons with an alternative method of visualization through smaller surgical corridors. One of the pioneers in minimally invasive spinal arthroscopy, Parviz Kambin, reported his results in patients with lateral recess stenosis. Of the 40 patients treated, 38 were available for follow-up, and a ''satisfactory'' result was obtained in 31 patients (82%) with minimal complications [35]. In addition, surgeons have reported excellent results in large case series using percutaneous approaches combined with laser application [36,37].

Minimal access technology and the microendoscopic tubular retractor system

Access to the spine has traditionally relied on wide exposure with paraspinal muscle retraction. Studies have demonstrated a loss of density in the lumbar spinal muscles on review of postoperative CT imaging as well as increases in intramuscular pressure (IMP) and intramuscular perfusion pressure (IPP) recorded during decompressive surgery [38–43]. To reduce this iatrogenic damage caused by traditional retractors, a microendoscopic tubular retractor system (MetRx; Medtronic, Memphis, Tennessee) was designed. This minimal access system was first used to treat patients with lumbar disc herniations and offered a safe and effective alternative to the ''gold standard'' microdiscectomy [44,45].

The MetRx system was used in a cadaveric study to assess the feasibility of performing a decompressive laminectomy from a unilateral approach with a microendoscopic technique. In this study, the L1 to L4 laminae of four cadavers underwent one of four procedures consisting of (1) unilateral microscopic laminotomy, (2) bilateral microendoscopic laminotomy, (3) unilateral open laminotomy, and (4) bilateral open laminotomy. Guiot and colleagues [46] demonstrated through CT that excellent decompression of the neural elements could be achieved with microendoscopic laminotomy and was as effective as open laminotomy.

This technique was used to treat a series of 25 consecutive patients with classic symptoms of lumbar radiculopathy by one of the leading experts in the field of minimally invasive spine surgery, Richard G. Fessler. The patients were compared with a second group of 25 patients treated with open decompressive laminectomy. Patients undergoing the minimally invasive procedure reported resolution of back pain (16%) and improvement of symptoms (68%), but 16% of patients remained unchanged in regard to symptomatology. The results were similar to those of the open decompression group. In the minimally invasive group, the average blood loss was 68 mL and postoperative hospitalization was 42 hours compared with 193 mL and 94 hours, respectively, in the open group. The authors noted an increase in operative time in the minimally invasive group (109 minutes per level) compared with the open group (88 minutes per level). The increase in operative time is likely attributable to the learning curve associated with performing the new minimally invasive procedure [47]. There have been other reports of excellent results with only slight modifications of the technique [48,49].

Technique of microendoscopic decompression for stenosis

Selected patients with symptomatic lumbar stenosis who have not responded to traditional nonoperative measures may consider undergoing a microendoscopic decompression for stenosis (MEDS) procedure. After preoperative medical clearance, the patient is anesthetized and placed in a prone position on a radiolucent frame. A Jackson table (OSI, Union City, California) is used to allow for the use of a C-arm fluoroscopic unit. The lumbar region is prepared and draped in a sterile fashion after the patient has received preoperative antibiotics.

The surgical level is estimated with lateral fluoroscopy, and a 20-mm incision is carried down through the lumbosacral fascia. With the use of the MetRx tubular dilation system, a muscle-sparing dilation technique is employed. Briefly, a Kirschner wire (K-wire) is docked on the facet overlying the surgical site, and sequential dilators are then used to spread the muscle. An 18-mm working channel is then placed over the dilators and locked into place, and the endoscope is attached (Fig. 2). Lateral fluoroscopic imaging verifies the location of the working channel and surgical level. A long insulated Bovie electrocautery is used to remove the soft tissue overlying the lamina and medial facet.

A sublaminar dissection is performed with the use of straight and angled curettes. A 40°-angled 3-mm Kerrison rongeur is used to perform a hemilaminotomy (Fig. 3A). This decompression is extended rostrally so that the insertion of the ligamentum flavum is detached, allowing for removal of the ligament. The decompression is enlarged medially by undercutting the base of the spinous process with the use of a high-speed drill

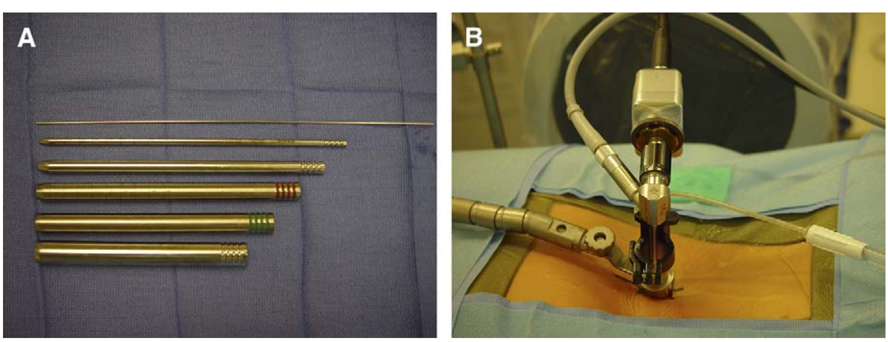

Fig. 2. Microendoscopic setup, including MetRx dilators (Medtronic, Memphis, Tennessee) (*A*) and an 18-mm working channel with a 30° endoscope (*B*).

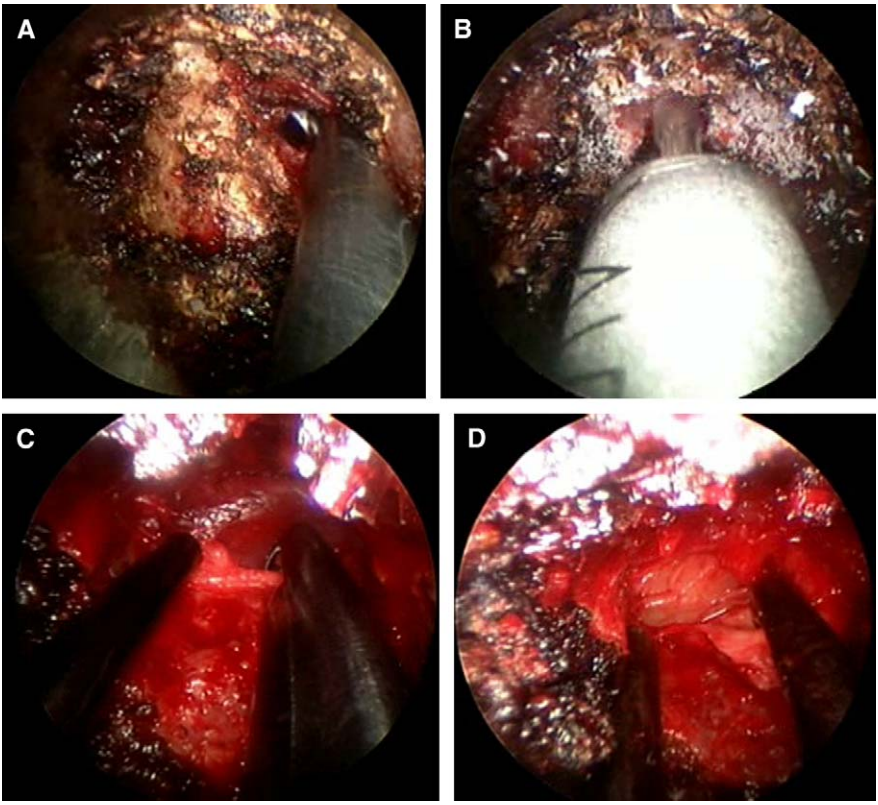

Fig. 3. Microendoscopic image of hemilaminotomy (*A*), drilling of the spinous process (*B*), removal of the hypertrophied ligamentum flavum (*C*), and the thecal sac after decompression (*D*).

(Fig. 3B). The medial aspect of the facet is then drilled to allow for decompression of the ipsilateral nerve root.

Once the laminectomy and medial facetectomy have been performed, attention is turned toward removal of the ligamentum flavum. The hypertrophied ligament is removed with a Kerrison rongeur in a piecemeal fashion, exposing the thecal sac (Fig. 3C). The lateral aspect of the ligament is removed, and a foraminotomy is performed to ensure neural decompression and is verified with a right-angled dissector (Fig. 3D). Next, the working channel and endoscope are removed, and the wound is irrigated with antibiotic solution. The lumbosacral fascia, dermis, and skin are closed with absorbable suture.

Instability associated with stenosis

Lumbar stenosis is commonly associated with patients who have evidence of spondylolisthesis. Many of these patients present with symptoms consistent with intermittent claudication or radiculopathy as well as with axial low back pain and may be candidates for minimally invasive decompression with fusion. Controversy exists when determining the indication for fusion and usually depends on the surgeon's training [50–55]. It is the author's preference to perform only decompression in patients with radicular symptoms and no evidence of instability as assessed on dynamic imaging. Patients who have a major component of back pain with evidence of instability are usually treated with a minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) (Fig. 4).

Adjacent level stenosis

Iatrogenic lumbar stenosis may result at levels adjacent to previous surgical fusions. The factors associated with the development of adjacent

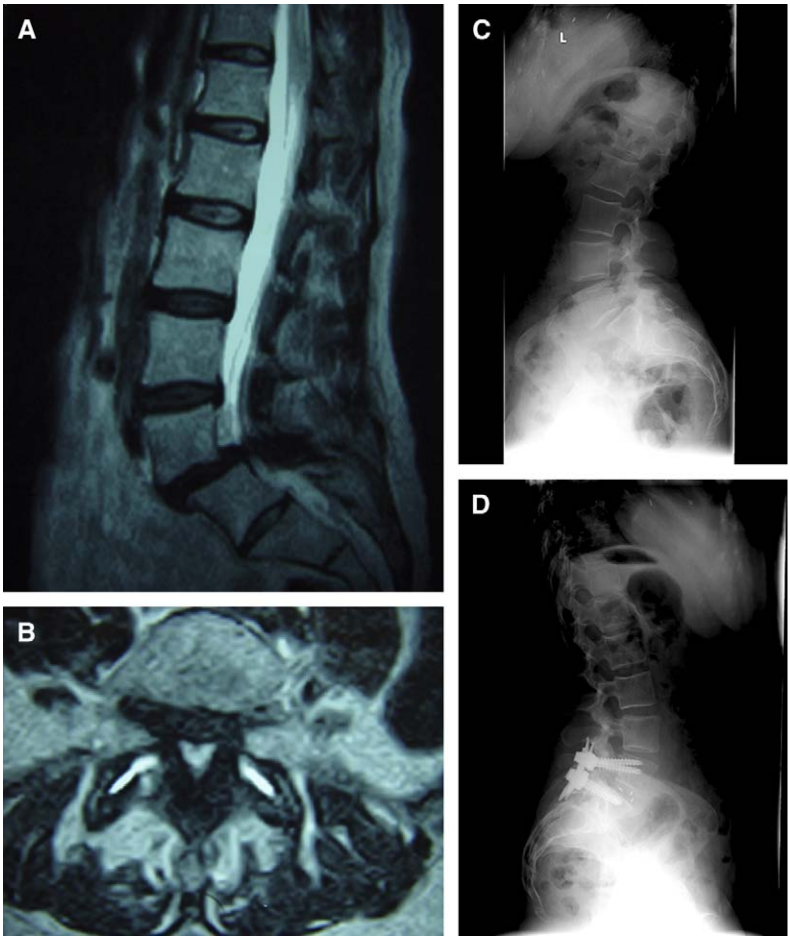

Fig. 4. Preoperative sagittal (*A*) and axial (*B*) MRI scans of a patient with grade I spondylolisthesis and stenosis, a preoperative lateral radiograph (*C*), and a postoperative lateral radiograph after MI-TLIF (*D*).

segment stenosis are not well established. It is reasonable that the additional stress transferred to the adjacent level leads to accelerated changes within the disc and facet complex [56]. Although the rates of degeneration at levels adjacent to fusions in the cervical spine have been well documented, the rate of lumbar degeneration is less clear [57,58].

Aiki and coworkers [59] retrospectively analyzed 117 patients who had undergone posterior fusion and were followed for a minimum of 2 years. Nine patients (7.7%) required an additional operation secondary to adjacent level stenosis with neurologic symptoms. Although this represents a small population, the only variable associated with a high rate of reoperation was multilevel fusion. In another retrospective study, adjacent segment degeneration was evaluated and found to occur in 17 (35%) of the 49 patients analyzed [60].

Patients who develop stenosis adjacent to previous fusion surgery are candidates for further decompression. Phillips and colleagues [61] reported the results of 33 patients who underwent surgical decompression at adjacent levels to previous fusion. In this retrospective review, 26 of the 33 patients were followed for 3 to 14 years, with a mean of 5 years, and were evaluated with an outcome questionnaire. Of the 26 patients, 15 rated their surgery as completely satisfactory, 6 were neutral toward the surgery, and 5 considered their surgery a failure. Interestingly, 6 of the patients required another surgical procedure during the follow-up period.

Minimally invasive treatment options can be used in the treatment of adjacent segment disease (Fig. 5). The feasibility of performing a microendoscopic decompression may rely on the ability to negotiate the working channel around the posterior instrumentation during the approach. The 18-mm working channel can usually be docked overlying the level of stenosis. Extension of the fusion at the adjacent level may be recommended if symptoms develop in the postoperative phase.

Treatment of synovial cysts with microendoscopic decompression for stenosis procedure

Degenerative lumbar stenosis may also be associated with the formation of synovial cysts [62–64]. The term *juxtafacet cyst* may be more appropriate, because the entity includes the synovial cyst that arises from degeneration of the facet joint and the ganglion cyst that arises from mucinous degeneration of the periarticular connective tissue. Although these cysts are relatively rare, reportedly occurring in 1% of 2898 patients who underwent MRI of the lumbar spine in one study, they can frequently be associated with clinical symptoms [65].

The most common presentation in patients harboring a synovial cyst is painful radiculopathy. Neurogenic claudication, sensory deficits, and motor weakness are also observed in patients with symptomatic synovial cysts [66]. These lesions have been successfully treated through numerous percutaneous procedures [67–70]. Surgical resection may

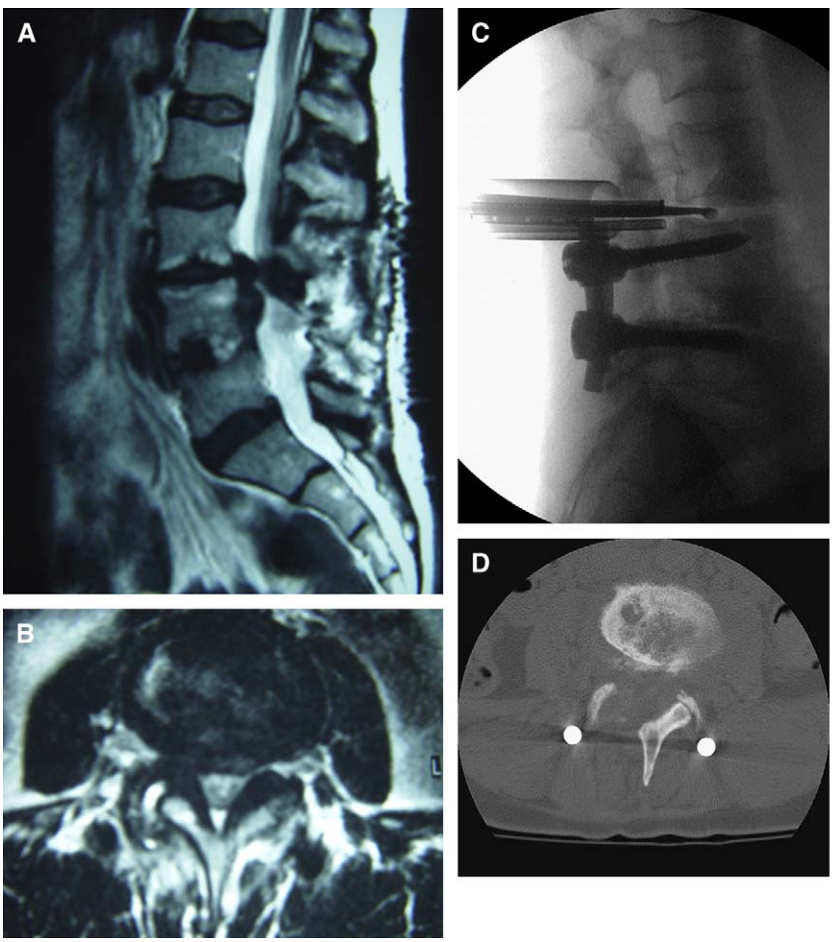

Fig. 5. Adjacent level stenosis on sagittal (*A*) and axial (*B*) MRI scans, intraoperative radiography depicting microendoscopic decompression with discectomy (*C*), and a postdecompressive axial CT scan (*D*).

offer the best and most definitive outcome, however [71–73].

A retrospective study of 194 patients treated with open decompression at the Mayo Clinic has been reported with excellent clinic results and low morbidity. Of the 194 patients evaluated, follow-up data were available for 147; 134 (91%) reported good relief of their pain, and 82% experienced improvement in their motor deficits. Although concomitant fusion was performed in 18 patients demonstrating evidence of instability, subsequent fusion was required in only 4 patients who developed symptomatic spondylolisthesis after decompression [66].

Synovial cysts have also been treated using minimally invasive techniques (Fig. 6). Sandhu and coworkers [74] reported their results in 17 patients treated for symptomatic synovial cysts using the MetRx tubular retraction system. In their hands, the procedure could be performed in an average of 97 minutes with an average minimal blood loss of 35 mL. Excellent or good results were observed in 94% of patients using the modified MacNab criteria. The authors observed grade I spondylolisthesis in 47% of the patients; however, only 1 patient required a subsequent fusion secondary to symptomatic spondylolisthesis. The authors concluded that this type of minimally invasive surgery may minimize the risk of progressive instability in patients with synovial cysts and concomitant spondylolisthesis.

New option in the treatment of lumbar stenosis

Although the breadth of this article is devoted to minimally invasive decompression for stenosis, there are minimally invasive techniques under evaluation that may offer symptomatic relief for patients with LSS without undergoing decompressive surgery. An interspinous distraction device has been available in Europe since June 2002 and has also been evaluated in clinical trials in the United States. The device, the X STOP (St. Francis Medical Technologies, Concord, California), can be placed through minimal access techniques and has demonstrated radiographic as well as clinical improvement. Lee and

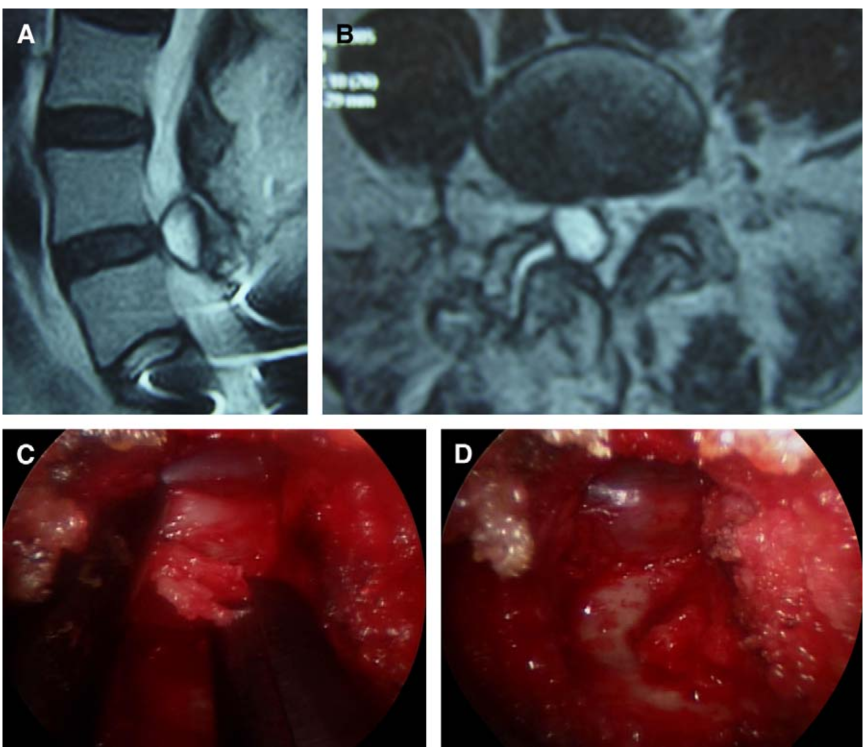

Fig. 6. Synovial cyst as depicted on axial (*A*) and sagittal (*B*) MRI scans, an intraoperative image of synovial cyst resection (*C*), and complete removal of cyst (*D*).

colleagues [75] have reported a cross-sectional increase in postoperative versus preoperative imaging of an average of 22.3% and an intervertebral foramina increase of an average of 36.5% in 10 consecutive cases. A prospective, randomized multicenter study involving 191 patients (100 received X STOP, and 91 were in the nonoperative control group) has been reported with 1-year success rates of 59% and 12%, respectively [76]. This trend was also observed at 2 years with a satisfaction rate of 73.1% in patients receiving the X STOP procedure compared with 35.9% in the control group [77].

Summary

With the increasing elderly population, the number of patients presenting with symptoms secondary to lumbar stenosis can be expected to increase accordingly. Therefore, treatment of this disease process should become more prevalent, and the minimally invasive techniques offer another treatment option. With increasing experience in minimally invasive techniques, the reported advantages of the minimal access surgery, including reduction in soft tissue injury, less blood loss, shorter hospitalization, and faster recovery, should make this an attractive alternative to traditional open surgery. Continuing efforts in the minimally invasive field can be expected to yield new and potentially less invasive as well as possibly more efficacious treatment options in the future.

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